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Forecast for Northern British Columbia coho salmon in 2003.

Prévisions pour le saumon coho du nord de la Colombie-Britannique pour 2003.

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Abstract

This Research Document documents abundance trends and forecasts of marine survival for the coho of northern coastal British Columbia (Statistical Areas 1 to 6), including the upper Skeena conservation area.

Observed Marine Survival in 2002:

Due to problems with the MRP database, marine survival for 2002 could not be determined at time of publication.

Forecasted Marine survival for 2003:

In 2003, marine survival at the three northern indicators is expected to be above or equal to the means of their respective periods of observation.

indicator	model	S_{2003} (50% CI)	observed mean and period of observation (year of sea-entry)
Lachmach	sibling regression	0.130 (0.108-0.157)	0.10 (1987 – 2000)
Toboggan Creek hatchery	from Lachmach	0.044 (0.028-.068)	0.039 (1987 – 2000)
Fort Babine hatchery	from Lachmach	0.023 (0.014-0.035)	0.025 (1993 – 2000)

The period of observation is short for all three indicators. The survival rate of wild Toboggan Creek coho should be comparable to Lachmach but cannot be reliably forecast.

2003 Abundance forecast

Estimated smolt production from Lachmach in 2002 was 2.7×10^4, which is below the observed mean of 3.1×10^4 (1987 – 2000). That combined with above-mean marine survival produce a forecast return of 3.5×10^3 (50%CI: 2.9×10^3 - 4.2×10^3) which is above mean (2.8×10^3) return observed over the period 1988 to 2002 (return years). The forecast of abundance for wild Toboggan coho is 1.8×10^3, which is considerably less than the mean total return of 4.7×10^3 (return years 1988 – 2002). Assuming an exploitation rate of 16% (i.e., same as 2002), the wild escapement to Toboggan would be 1.5×10^3, including terminal sport fisheries. That escapement is considerably below the mean of the available observations (2.1×10^3; 1988 –2002). Abundance of Ft. Babine hatchery coho is forecast to be 6.8×10^2 (50%CI: 4.3×10^2 – 1.1×10^3). This return is below the mean of the time series (1.0×10^3; 1994 to 2001). Assuming an exploitation rate of 0.21, the mean exploitation rate of Lachmach, Toboggan and Zolzap in 2002, escapement of Ft. Babine hatchery coho would be 5.3×10^2.

The time series of abundance and the average-stream indices of the 6 north coastal aggregates show some indication of geographic patterning but do not indicate any conservation concerns in the area, with the possible exceptions of Area 4 upstream of the Babine confluence and Area 5. Escapement data are very poor in these Areas so it is difficult to determine the extent to which the poor escapements are due simply to limited data. The total abundance and the escapement of coho to the Lachmach River, Toboggan Creek and Ft. Babine hatchery will be average to above-average in 2003. Without further investigation and a demonstration that status is actually better than indicated by the index used here, expansion of fisheries in the northern part of the coast should be discouraged.

Résumé

Ce document de travail porte sur les tendances de l'abondance et les prévisions de la survie en mer du coho des zones côtières nordiques de la Colombie-Britannique (zones statistiques 1 à 6), y compris l'aire de conservation de la Haute-Skeena.

Taux observé de survie en mer en 2002 :

À cause de problèmes avec la base de données MRP, le taux de survie en mer en 2002 n'a pu être établi au moment de la publication du document.

Taux prévu de survie en mer en 2003 :

On s'attend à ce que le taux de survie en mer en 2003 aux trois indicateurs nordiques se situe au niveau de la moyenne ou au-dessus de ce niveau pour les périodes respectives d'observation.

Indicateur	Modèle	S_{2003} (IC 50 %)	Moyenne observée et période d'observation (année d'entrée en mer)	
Lachmach	Régression de fratrie	0,130 (0,108-0,157)	0,10	(1987 – 2000)
Écloserie du ruisseau Toboggan	de Lachmach	0,044 (0,028-0,068)	0,039	(1987 – 2000)
Écloserie de Fort Babine	de Lachmach	0,023 (0,014-0,035)	0,025	(1993 – 2000)

La période d'observation pour les trois indicateurs est courte. Le taux de survie du coho sauvage du ruisseau Toboggan devrait être comparable à celui du coho de la rivière Lachmach, mais on ne peut pas le prédire avec précision.

Prévision de l'abondance en 2003

Selon les estimations, la production de smolts dans la rivière Lachmach en 2002 se chiffrait à $2,7 \times 10^4$, soit un niveau inférieur à la moyenne observée de $3,1 \times 10^4$ (1987–2000). Ce niveau de production, joint au fait que le taux de survie en mer se situait au-dessus de la moyenne, donne une remonte prévue de $3,5 \times 10^3$ cohos (IC à 50 % : $2,9 \times 10^3 - 4,2 \times 10^3$), soit une remonte au-dessus de la moyenne observée ($2,8 \times 10^3$) pour la période allant de 1988 à 2002 (années de remonte). Selon les prévisions, l'abondance de cohos sauvages dans le ruisseau Toboggan atteindrait $1,8 \times 10^3$, ce qui est considérablement moins que la remonte totale moyenne de $4,7 \times 10^3$ (années de remonte 1988–2002). Si l'on suppose que le taux d'exploitation atteindra 16 % en 2003 (soit le même niveau qu'en 2002), l'échappée de cohos sauvages dans le ruisseau Toboggan se chiffrera à $1,5 \times 10^3$, y compris les pêches récréatives en estuaire. Cette échappée est sensiblement inférieure à la moyenne des observations disponibles ($2,1 \times 10^3$; 1988–2002). On prévoit que l'abondance du coho issus de l'écloserie de Fort Babine atteindra $6,8 \times 10^2$ (IC à 50 % : $4,3 \times 10^2 - 1,1 \times 10^3$). Cette remonte est inférieure à la moyenne de la série chronologique ($1,0 \times 10^3$; 1994-2001). Si l'on suppose que le taux d'exploitation atteindra 0,21 en 2003, soit le taux d'exploitation moyen du coho de la rivière Lachmach, du ruisseau Toboggan et du ruisseau Zolzap en 2002, l'échappée de cohos de l'écloserie de Fort Babine se chiffrera à $5,3 \times 10^2$.

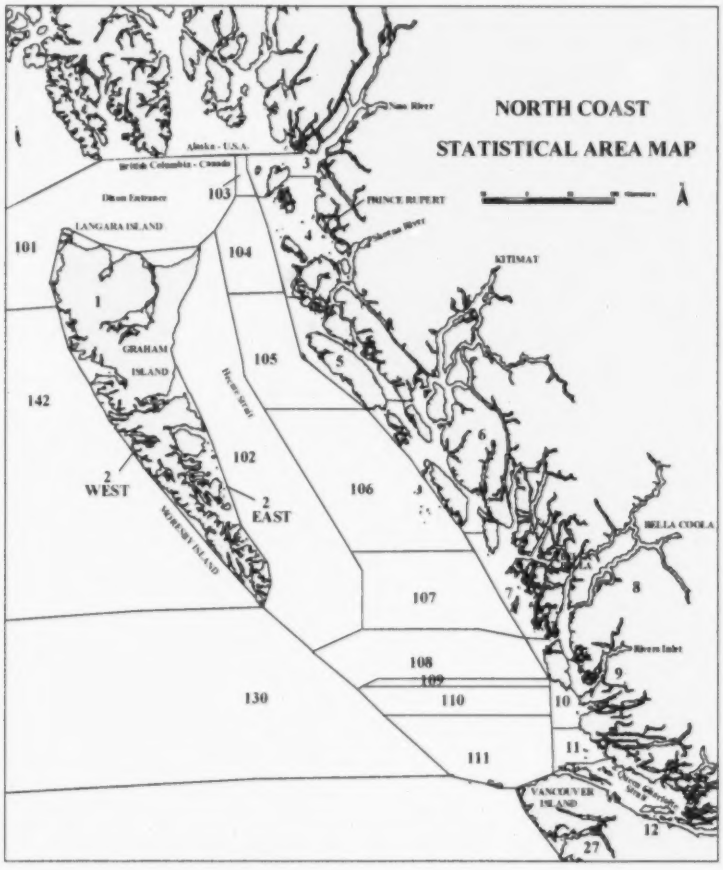
La série chronologique d'indices d'abondance et d'indices moyens pour les cours d'eau pour les six zones côtières nordiques révèle une certaine structure spatiale, mais aucun problème de conservation, sauf peut-être dans le cas de la zone 4 en amont de la confluence avec la rivière Babine et la zone 5. Comme on dispose de peu de données sur les échappées dans ces zones, il est difficile de déterminer dans quelle mesure les faibles échappées sont simplement imputables à cette carence. L'abondance totale et l'échappée de cohos dans la rivière Lachmach, le ruisseau Toboggan et l'écloserie de Fort Babine se situeront au niveau de la moyenne ou au-dessus en 2003. En l'absence d'autres études démontrant que l'état du coho est réellement meilleur que ne le révèle l'indice ci-utilisé, l'expansion des pêches dans cette partie de la côte n'est pas indiquée.

1. Introduction

In this Research Document we detail:

1. Trends in abundance and marine survival for the North Coast coho salmon (Statistical areas 1- 6);
2. A forecast of marine survival and total return for the wild indicator stock of the Lachmach River (Area 3; Work Channel);
3. Forecasts of marine survival for the Toboggan Creek and Fort Babine hatchery indicators (Area 4; upper Skeena conservation area);
4. Forecasts of the return and escapement of hatchery fish to Babine Lake (Area 4; upper Skeena conservation area;
5. Forecasts of the total escapement of wild coho to statistical areas Area 2 East, 2 West and Area 6.

Forecasting methods conform to those of past forecasts in this area (Holtby and Finnegan 2002; Holtby et al. 2000, 1999a).



2. Data Sources

Catch data for coded-wire tagged coho from the Lachmach River, Zolzap Creek, Toboggan Creek and Fort Babine hatchery indicators were obtained from online databases maintained by the Alaskan Dept. of Fish and Game[1] and Fisheries and Oceans Canada[2]. CWT recovery data for 2002 is problematic and will change as catch and escapement estimates are finalized. Escapement data for Lachmach River coho and Visual escapement estimates for streams in Statistical Areas 1 to 6 were obtained from stock assessment staff in the Prince Rupert Office. Escapement data for the Babine Lake coho aggregate were obtained from a database maintained by the Stock Assessment Division in the Prince Rupert Office. Escapement data for Toboggan hatchery and wild coho were obtained from the Toboggan Creek Enhancement Society (pers. comm. M. O'Neill). LGL LTD[3] provides escapement data for Zolzap Creek. Escapement data for the Sustut are courtesy of the Fisheries Branch of the Ministry of Water, Lands and Parks Skeena Region. Upper Bulkley fence data are courtesy of Brenda Donas Fisheries & Oceans Canada, Smithers, B.C. All data from 2002 should be considered preliminary and subject to revision as escapement estimates are finalized.

The practice of releasing adipose-clipped coded-wire tagged fish (AdCWT) fish with additional right maxillary clips, in use since 1998, on Babine hatchery fish was discontinued for the 2001 brood year. Babine hatchery maxillary clips are known to reduce survival by 25% to 33% compared to AdCWT coho of similar size (D. Bailey, HEB, Vancouver)

Estimates of exploitation rate are based partially on the recoveries of CWT's in Alaskan and Canadian fisheries and on estimates of exploitation rate derived from reconstructions of Skeena/Nass River sockeye fisheries in Statistical Areas 1 to 5 (pers. comm. S. Cox-Rogers, DFO, Prince Rupert).

3. Abundance Estimators

3.1 Escapement trends

Four indicator sites are used to determine the status of North Coast coho. They are: Zolzap Creek which drains into the Nass River, Lachmach River at the head of Work Channel, the Toboggan Creek CDP project located on a lower tributary to the Bulkley River, and the Fort Babine CDP project on Nilkitkwa Lake, part of the Babine Lake system.

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[1] Alaska Department of Fish and Game, Commercial Fisheries: http://tagotoweb.adfg.state.ak.us
[2] Fisheries & Oceans Canada, MRP program.
[3] LGL Limited 9768 2nd St. Sidney, BC V8L 3Y8

In addition to the indicator sites, escapement estimates from fence counts exist for the following systems: Babine, collected on the Babine River below Nilkitkwa Lake; Upper Bulkley, collected on the Bulkley River at Houston, B.C.; and the Sustut River, a tributary to the Skeena upstream of the Babine confluence.

Where fence counts do not exist, visual escapement counts are used. Estimates of escapement to individual streams throughout BC have been made since at least 1950. These estimates are mostly based on visual inspections of the streams. The methods used to inspect the streams, and convert the counts to estimates of escapement, the frequency of surveys, etc., are largely undocumented. These methods are known to differ between systems and to have changed over time. The records are also fragmentary. Nevertheless we think that the time series do contain information about escapement trends in each area.

To extract that information we first coded the various designators for "no-data" to a common missing value indicator. We then scaled the escapement (E) in each stream i to the maximum escapement recorded in that stream across all years t:

$$p_{i,t} = \frac{E_{i,t}}{\max(E_i)} \tag{7}$$

Then the $p_{i,t}$ were averaged across all streams i within each year t to give a time series (p_{max}) for the area as a whole. The "average-stream" or index escapement was constructed by multiplying p_{max} by the average across the i streams of $\max(E_i)$. This procedure was carried out for streams aggregated by Statistical Area. The 95% confidence limits of the p_{max} value were calculated as:

$$\pm t_{crit} \times \sigma / \sqrt{n}$$

3.2 Escapement estimates

3.2.1 Fence Counts

3.2.1.1 Zolzap Creek

The Zolzap Creek indicator site has been in continuous operation since 1992 and provides an index of stock status for Area 3. The methodology and data are summarized in annual reports (Baxter and Stephens 2002). In 2002 the escapement was the highest on record at 2977 fish (see figure 2). No estimate of the confidence around the estimate is given.

3.2.1.2 Lachmach River

The Lachmach River indicator site has been in continuous operation since 1988. Although geographically located in Area 3, it is used as an index of abundance for the lower Skeena (Area 4). The methodology

and data are detailed in a series of manuscripts (Taylor, J.A. 2001 and references within). Similar to Zolzap Creek, the escapement in 2002 was the highest on record with 3278 (95% CI 3149- 3324). The escapement has been steadily increasing since 1997 (see figure 3).

3.2.1.3 Toboggan Creek

The Toboggan Creek CDP project has been performing adult escapement counts since 1988. For 2002, the wild escapement was estimated to be 2972 coho with an additional escapement of 1008 hatchery fish. The wild escapement is the third highest on record (see figure 4).

3.2.1.4 Ft. Babine CDP

The Fort Babine CDP indicator stock produces hatchery fish raised in in-river pens. The 2001 brood year suffered 100% mortality before release and no data is available for 2002.

3.2.1.5 Upper Bulkley

The Upper Bulkley fence has data from 1996 to 2002. The escapement estimates have varied by 2 orders of magnitude in that time with a 2002 escapement estimate of 990 coho (see figure 6).

3.2.1.6 Babine Fence

The Babine coho escapement estimate was incomplete in 2002 due to unforeseen circumstances. The estimate of 13,613 fish is an extrapolation based on the average run timing of the last 4 years and is the 4th highest escapement estimate since 1946 (see figure 5).

3.2.1.7 Sustut Fence

The Sustut Fence has been monitoring coho escapement since 1992 and has experienced escapements as low as 5 fish in 1997. For 2002, the escapement was the third highest in the 11 year time series but was only 64 fish in total (see figure 7).

3.2.2 Visual Escapement Estimates

3.2.2.1 Area 1

The visual escapement estimates for Area 1 suffer from a low number of streams sampled; in 2002 the Pmax calculation was based on only 2 streams. As a consequence, since 1998 the uncertainties surrounding the estimates prevent any interpretation of trends in escapement (see figure 8).

3.2.2.2 Area 2W

The Area 2W visual escapement estimates show a significant increase in escapements over the period 1990-1997. The number of streams sampled throughout this period has remained relatively high, 15-20 streams, which provides for tighter confidence limits around the escapement estimates (see figure 9).

3.2.2.3 Area 2E

The visual escapement estimates for Area 2E have displayed a noticeable, although not always statistically significant, increase since 1997. The number of sampled streams remains above 20; this appears to be insufficient to detect population differences between successive years. (see figure 10)

3.2.2.4 Area 5

The visual escapement estimates for Area 5 suffer from a low number of streams sampled. Due to the high uncertainty around the estimates, there are no detectable trends in escapement since 1997. (see figure 11)

3.2.2.5 Area 6

There has been a significant increase in escapement in Area 6 since 1997. The relatively large number of sampled streams provides an accurate indication that the overall decline in escapement since the early 1970s has stopped and the stock is now rebuilding. (see figure 12)

4. Forecasting Methodology

4.1 Forecasting models

4.1.1 Sibling Regression

For Lachmach River coho the marine survival rate was predicted using a "sibling-regression" model, where the total return of age-n.1[4] fish ($A_{t,n.1}$) is predicted from the observed age-n.0 escapement of males ($E_{t-1,n.0}$, 'jacks'):

$$\log_e A_{t,n.1} = b \log_e E_{t-1,n.0} + a + \varepsilon_t \qquad (6)$$

[4] The age designation follows the European convention, which is "number of fresh water winters . number of ocean winters". In most northern coho, escapement and catch is made up of a mixture of age 1.1 and age 2.1 adults with some age 3.1 animals.

Survival (s_{smolt}) was then calculated by dividing the age-n.1 return in year t by the number of smolts counted out of the system in year t-1 (N_{smolt}).

We know from patterns of CWT recoveries that fish from the lower and middle Skeena are more similar to coho from the more southerly Areas, while fish from the Babine have similar distributions to Area 3 coho. We therefore assumed that the marine exploitation rate time series developed for Toboggan Creek was applicable to all areas except 3 and the upper Skeena. The exploitation rate time series for Area 3 was derived from Lachmach 1987-2002 and from the marine component of Babine from 1950 to 1986. The exploitation rate for the upper Skeena was the average of those for Babine and Toboggan. In using the exploitation rate time series for Skeena populations, the fresh water components of those exploitation time series were removed before application to the other areas.

4.1.2 Time-series forecasts

The forecasting of escapement for Areas 2W, 2E and 6 was performed using a 3-year running average (3YRA). The variable being forecast (v) is first transformed so that

$$Z = \Im(v) \qquad (1)$$

where $\Im$ is the transformation and Z is the transformed value of v. The Log transformation was used for escapement. The model is as follows where Z_{t+1} is the forecast value for time t+1:

$$Z_{t+1} = \frac{\sum_{k=t-2,t} Z_k}{3} + \varepsilon_t$$

For each model we assume that the error term is normally distributed $\left(\varepsilon \sim N(0,\sigma^2)\right)$ and is independent of time. For the purpose of estimating uncertainty in the forecast value (Z_{t+1}), an estimate of σ^2 was obtained for the distribution of observed minus predicted for years $1...t$.

5. Marine Survival Estimates

5.1 2002 Observed marine survivals

Due to problems with the MRP program, the 2002 observed marine survivals from the indicator stocks cannot be presented with any confidence.

5.2 2002 Forecasts compared to 2002 observed marine survivals.

The performance of the 2002 forecasts can not be evaluated until the MRP expansion factors are determined.

5.3 2003 Marine Survival Rate Forecast

Survivals for all three northern indicators are expected to be above the means of their respective time series in 2003 (2002 sea-entry). The forecast for the total return of Lachmach coho was made with the following sibling regression:

$$\log_e(A\ \text{n.1}) = 5.906 + 0.369\log_e(E\ \text{n.0})$$
$$(N = 13;\ \text{adj.}\ r^2 = 0.52;\ P < 0.005)$$

The estimated jack escapement ($E_{n.0}$) in 2002 to Lachmach was 413, which leads to a forecast total return of 3.6×10^3, which is well above the mean of the available observations (Table 1; 1989 to 2002 returns). The 2002 smolt run at Lachmach was estimated to be 2.6×10^4 leading to a marine survival forecast of 0.13, which is above the mean of 0.100 (Table 1; 1987 to 2000 sea-entry). The confidence intervals for the Lachmach survival and abundance forecasts are detailed in Table 2. Very few or no jacks return to interior sites so sibling regression is not possible for either Babine or Toboggan Creek. However, the temporal patterns in marine survival are similar for the three northern indicators (Table 1), allowing us to use the Lachmach forecast to predict survivals in the two Skeena indicators. The relationship between Lachmach and Toboggan survivals:

$$\text{logit}\left(s_{Toboggan}\right) = 0.933\text{logit}\left(s_{Lachmach}\right) - 1.30$$
$$(N = 14;\ \text{adj.}\ r^2 = 0.40;\ P < 0.01),$$

gives a forecast survival at Toboggan of 0.044 (50%CI: 0.028 – 0.069; Table 2). That survival is above the mean of the time series (0.039 for the period 1987 to 2000 sea-entry). Note that the uncertainty is a minimal estimate because the uncertainty in the forecast of Lachmach survival is not taken in to account.

The wild smolt output from Toboggan Creek in 2002 was estimated to have been 4.0×10^4. The variability of the ratio between observed hatchery and estimated wild survival (see Table below) is large but the ratio appears to be decreasing. If the scalar is set to the average of the last three observations, the wild survival should be around 3.1% and the total wild return would be 1.24×10^3. Assuming an exploitation rate of 36%

smolt year	estimated wild smolt number ($\times 10^3$)	ratio of wild to hatchery marine survival	estimated wild survival
1995	38	3.895	0.097
1996	35	3.97	0.020
1997	42	3.61	0.067
1998	67	1.15	0.12
1999	44	1.66	0.074
2000	89	0.74	0.061
2001	44	est. 1.18	forecast 0.031

(i.e., same as 2001), the wild escapement to Toboggan would be 8.0×10^2, including terminal sport fisheries. That escapement is considerably below the mean of the available observations (2.1×10^3 ; 1988 –2002), but is only slightly below a recently recommended *MSY* escapement target of 900 coho (Shaul and Van Allen 2001).

The relationship between survival of Lachmach and Fort Babine hatchery coho is weaker largely because of the smaller time series and lower than expected survival for the 1995 brood year (Table 1) but is improving as the time series lengthens. The predictive relationship is

$$\text{logit}(s_{Babine}) = 1.229\text{logit}(s_{Lachmach}) - 1.424$$

$$(N = 8;\ \text{adj. } r^2 = 0.48;\ P < 0.05)$$

The forecast survival for Babine coho is 0.023, which is similar to the mean of the time series (0.025, Table 2). Again note that the uncertainty is a minimal estimate because the uncertainty in the forecast of Lachmach survival is not taken into account.

6. Forecasts of abundance and escapement

6.1 Performance of the 2002 forecasts of abundance

As with the analysis of the forecasts of survival, the estimates of total returns for 2002 are dependant on the expansion factors of the MRP database which are in question at the time of publication.

6.2 2003 Abundance forecasts

The forecast abundance of Skeena calculated from the Lachmach sibling analysis can be characterized as average or better abundance and above average or better escapements. These groups include the most productive of the aggregates in the northern and central coastal areas and the coho in these areas have

responded strongly to reduced fishing pressure and several years of above-mean marine and fresh water survival. The only caveat on these forecasts is the continued weakness in some of the high interior populations of the upper Skeena typified by the Sustut River escapement indicator. The 2002 Sustut coho escapement estimate was 64 fish, well below the target escapement of 200 fish (B. Holtby, pers. comm). The observed low escapement may be related to low productivity and continued fishing pressure in the mixed-stock coho fishery.

6.3 2003 Escapement forecasts

The escapement forecasts for 2003 for Areas 2W, 2E and 6 were calculated using a 3YRA. The escapement predictions and the confidence around the predictions are listed in Table 3. The predicted escapement in relation to the long-term time series of escapements are displayed in Figures 14 – 16.

7. Conclusions

7.1 Marine survival

In 2003, marine survival at the three northern indicators is expected to be similar or above the means over their respective periods of observation.

indicator	model	S hat_{2003} (50% CI)	observed mean and period of observation (year of sea-entry)
Lachmach	sibling regression	0.130 (0.108-0.157)	0.10 (1987 – 2000)
Toboggan Creek hatchery	from Lachmach	0.044 (0.028-0.068)	0.039 (1987 – 2000)
Fort Babine hatchery	from Lachmach	0.023 (0.014-0.035)	0.025 (1993 – 2000)

The period of observation is short for all three indicators. The survival rate of wild Toboggan Creek coho should be comparable to Lachmach but cannot be reliably forecast.

7.2 Abundance forecast

Estimated smolt production from Lachmach in 2002 was 2.7×10^4 (95% CI 21,038 - 32,789). That combined with above-mean marine survival produce a forecast adult return of 3.6×10^3 (50%CI: 2.2×10^3 – 3.3×10^3) which is the mean of 2.7×10^3 observed over the period 1988 to 2002 (return years). Wild smolt production from Toboggan Creek in 2002 was estimated to have been 4.0×10^4. When combined with a forecast of above-mean marine survival the forecast of total wild return is 1.24×10^3, which is considerably less than the mean total return of 4.7×10^3 (return years 1988 – 2001). Assuming an exploitation rate of 36% (i.e., same as 2002), the wild escapement to Toboggan would be 8.0×10^2, including terminal sport fisheries. That escapement is considerably below the mean of the available observations (2.1×10^3; 1988 – 2002; *Z*-score = –0.88), but is only slightly below a recently recommended *MSY* escapement target of 900 (Shaul and Van Allen 2001).

8. References

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Table 1. Marine survival rate estimates at three northern BC coho indicators. Toboggan and Fort Babine are hatchery indicators. Lachmach is a wild indicator. The stock size for Toboggan Creek is the wild component only. Estimates for 2002 are unknown due to problems with the MRP database.

	Marine Survival				Estimated Returns			
adult return year	Lachmach	Toboggan	Fort Babine	Zolzap	Lachmach adults	Lachmach jacks	Toboggan	Zolzap
1988	0.030	0.021			2,146		1,689	
1989	0.044	0.027			1,590	250	5,498	
1990	0.113	0.041			4,116	445	8,842	
1991	0.121	0.060			4,194	81	8,125	
1992	0.088	0.017			1,679	64	5,897	
1993	0.061	0.028		0.020	2,065	421	3,638	2,832
1994	0.174	0.060	0.040	0.089	4,570	267	5,779	9,645
1995	0.082	0.018	0.010	0.035	3,223	513	2,736	3,057
1996	0.072	0.025	0.031	0.065	3,925	131	3,708	3,159
1997	0.055	0.005	0.006	0.022	1,728	78	691	1,072
1998	0.096	0.018	0.007	0.029	2,025	429	2,823	1,986
1999	0.125	0.104	0.051	0.073	2,437	130	7,872	2,808
2000	0.144	0.044	0.018	0.042	1,960	397	3,479	955
2001	0.136	0.083	0.033	0.076	2,733	229	5,491	3,765
2002	unknown	unknown	unknown	unknown	unknown	413	unknown	unknown

Table 2. Forecasts of 2002 sea-entry (2003 return) marine survival for three northern BC coho indicators and abundance for the Lachmach River, with associated confidence intervals. 'A' is total abundance while 's' is marine survival.

	Lachmach		Toboggan	Fort Babine
probability of smaller return or survival	$\hat{A}_{2002}$	$\hat{s}_{2002}$	$\hat{s}_{2002}$	$\hat{s}_{2002}$
99%	7.3E+03	0.272	0.214	0.14
95%	5.7E+03	0.212	0.131	0.074
90%	5.1E+03	0.188	0.102	0.055
75%	4.2E+03	0.157	0.069	0.035
50%	**3.5+03**	**0.130**	**0.044**	**0.023**
25%	2.9E+03	0.108	0.028	0.015
10%	2.4E+03	0.090	0.018	0.009
5%	2.1E+03	0.080	0.014	0.007
1%	1.7E+03	0.062	0.008	0.003

Table 3. Forecasts of 2002 sea-entry (2003 return) total escapment of coho for Statistical Areas 2E, 2W, and 6, with associated confidence intervals and Z-scores.

	Area 2E		Area 2W		Area 6	
P *	Forecast escapement	z-score	Forecast escapement	z-score	Forecast escapement	z-score
99%	7.52E+04	2.49	2.83E+04	7.77	1.02E+05	1.53
95%	5.11E+04	1.30	1.45E+04	3.62	6.68E+04	0.56
90%	4.19E+04	0.85	1.03E+04	2.35	5.38E+04	0.20
75%	3.02E+04	0.28	5.86E+03	1.02	3.77E+04	-0.25
50%	**2.12E+04**	**-0.17**	**3.17E+03**	**0.21**	**2.56E+04**	**-0.58**
25%	1.48E+04	-0.48	1.71E+03	-0.22	1.74E+04	-0.81
10%	1.07E+04	-0.68	9.74E+02	-0.44	1.22E+04	-0.95
5%	8.76E+03	-0.78	6.90E+02	-0.53	9.80E+03	-1.02
1%	5.95E+03	-0.92	3.54E+02	-0.63	6.43E+03	-1.11

*probability of a lower value

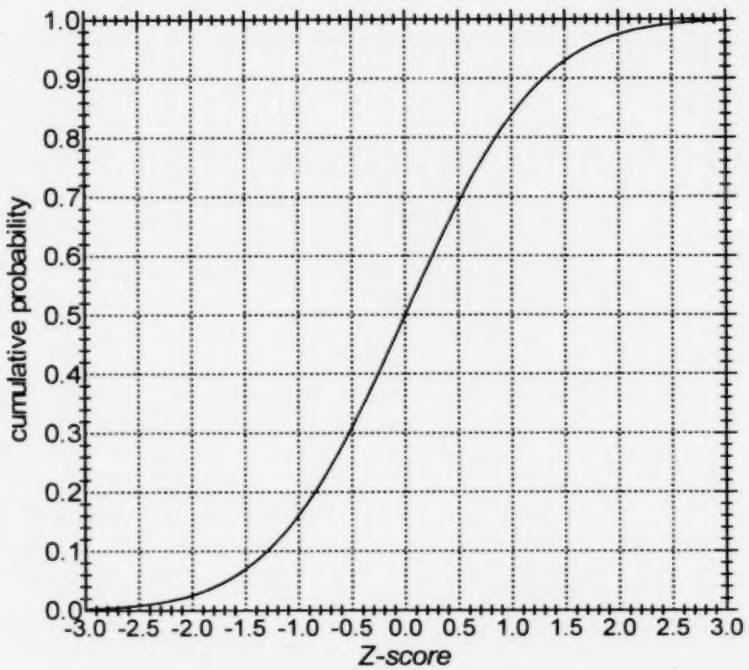

Figure 1. Cumulative probabilities for *Z*-scores applicable to the escapement time series of Statistical Areas 2W, 2E, and 6. This plot can be used to convert *Z-scores* to probabilities

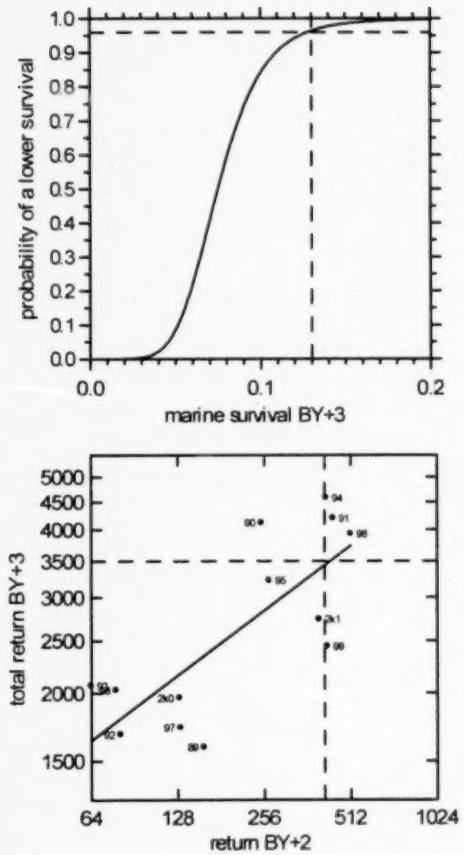

Figure 2. Return and survival forecast for Lachmach River coho in 2003 using the sibling regression model with data from 1989-2001. The lower panel is the sibling relationship. The upper panel is the probability distribution for the predicted marine survival.

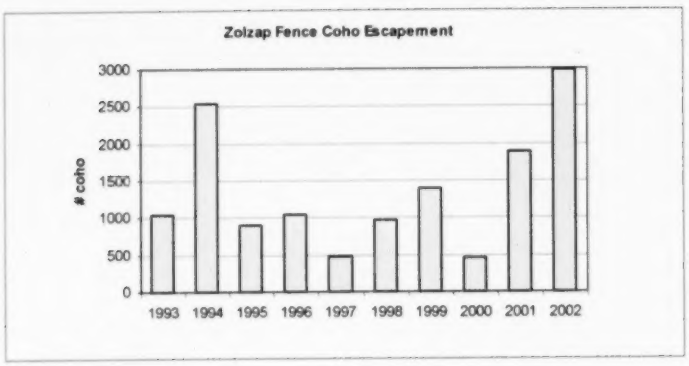

Figure 3. Time series of escapement of coho adults to Zolzap Creek (Area 3) from 1993 to 2002.

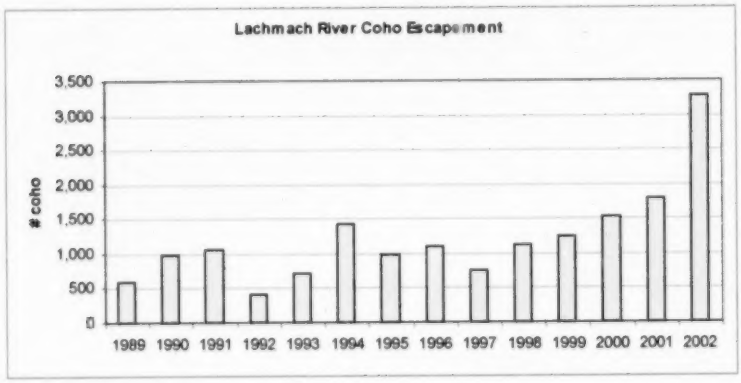

Figure 4. Time series of escapement of coho adults to Lachmach River (Area 3) from 1989 to 2002

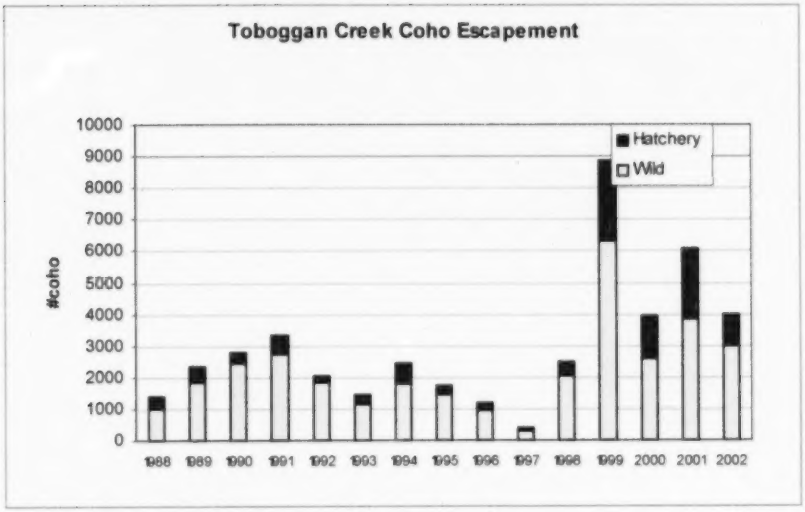

Figure 5. Time series of escapement of both hatchery and wild coho adults to Toboggan Creek (Area 4) from 1988 to 2002.

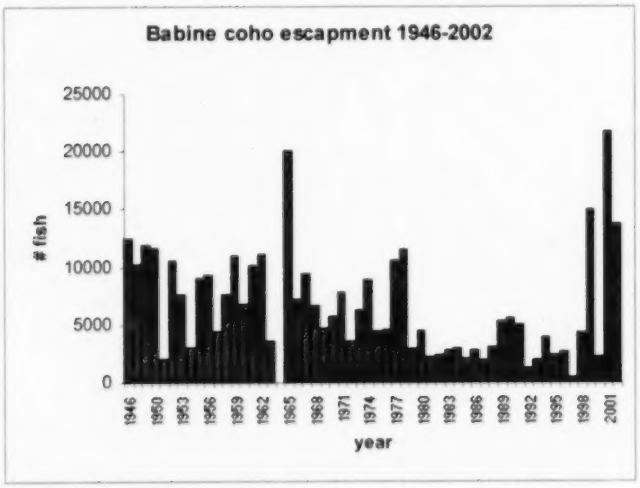

Figure 6. Time series of escapement of coho adults to Babine River (Area 4) from 1946 to 2002.

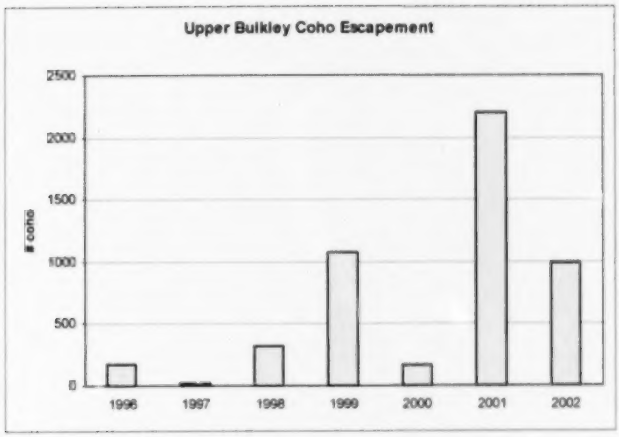

Figure 7. Time series of escapement of coho adults to the Upper Bulkley River (Area 4) from 1996 to 2002

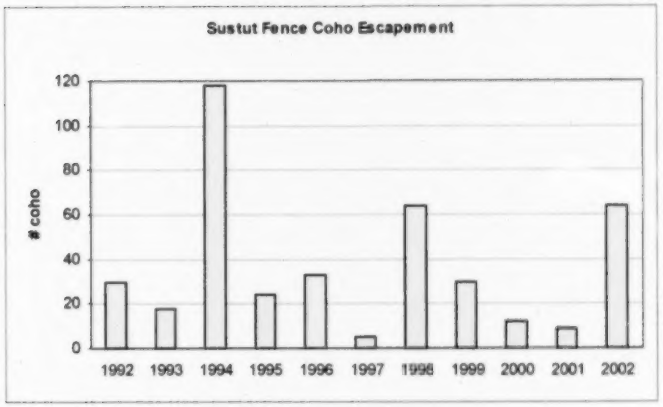

Figure 8. Time series of escapement of coho adults to Sustut River (Area 4) from 1992 to 2002.

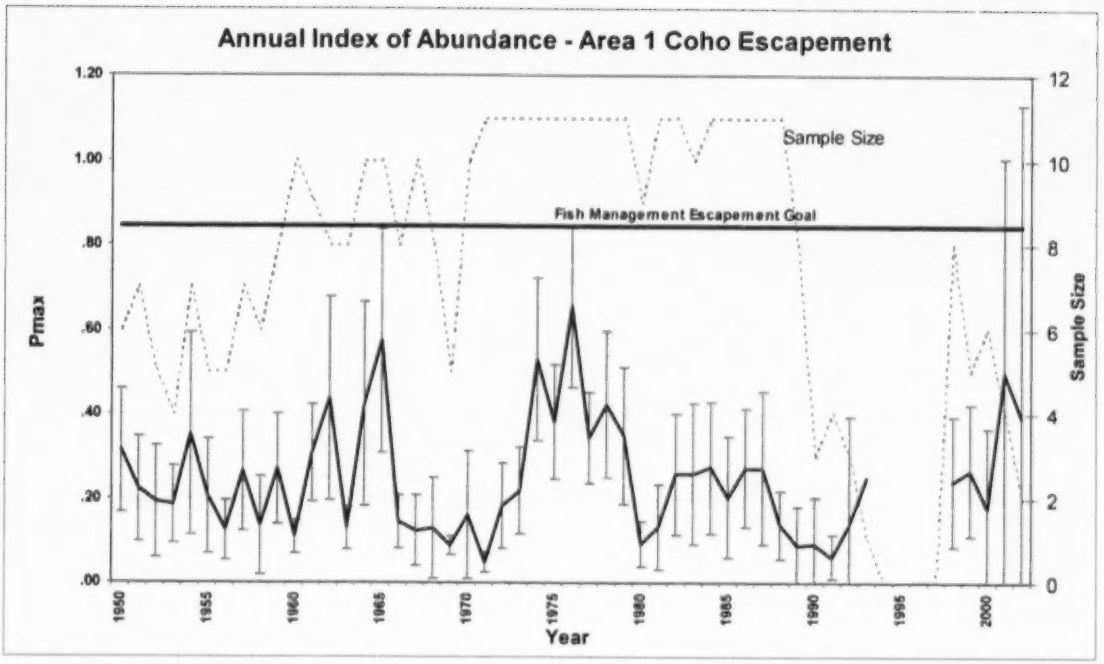

Figure 9. Time series of escapement estimates based on visual surveys of coho adults to Area 1 from 1950 to 2002. Solid line is the escapement estimate expressed as a Pmax value. Dotted line is the number of streams used to calculate the Pmax value. Error bars are the 95% confidence limits for the Pmax escapement estimate.

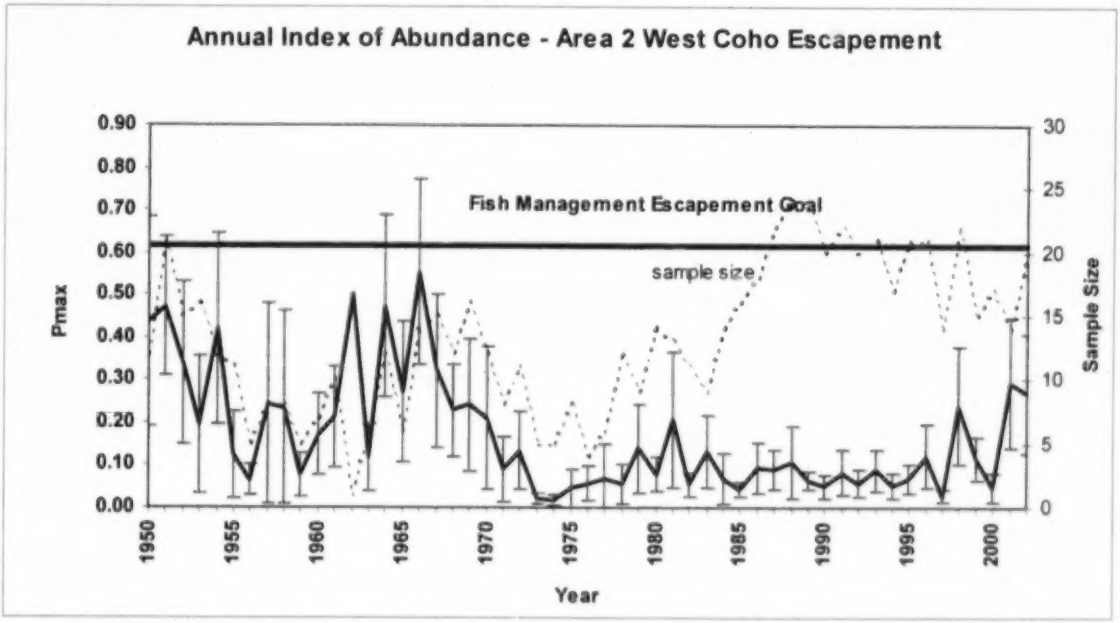

Figure 10. Time series of escapement estimates based on visual surveys of coho adults to Area 2W from 1950 to 2002. Solid line is the escapement estimate expressed as a Pmax value. Dotted line is the number of streams used to calculate the Pmax value. Error bars are the 95% confidence limits for the escapement estimate.

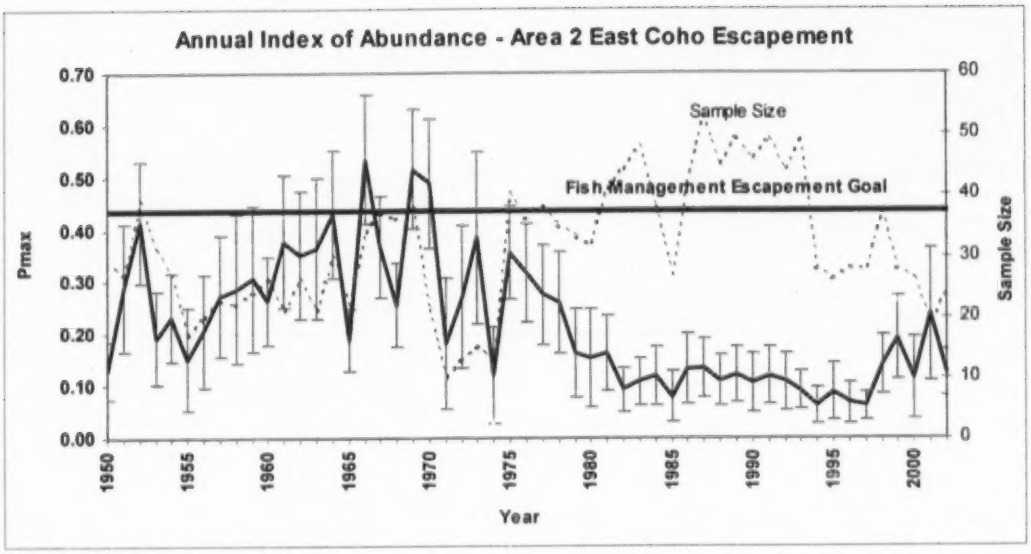

Figure 11. Time series of escapement estimates based on visual surveys of coho adults to Area 2E from 1950 to 2002. Solid line is the escapement estimate expressed as a Pmax value. Dotted line is the number of streams used to calculate the Pmax value. Error bars are the 95% confidence limits for the escapement estimate.

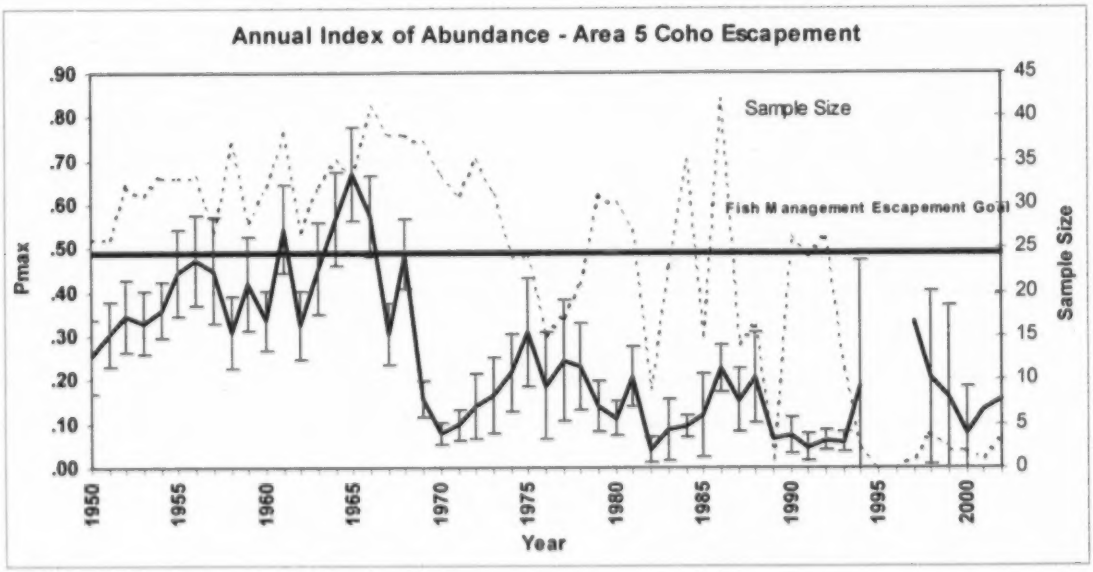

Figure 12. Time series of escapement estimates based on visual surveys of coho adults to Area 5 from 1950 to 2002. Solid line is the escapement estimate expressed as a Pmax value. Dotted line is the number of streams used to calculate the Pmax value. Error bars are the 95% confidence limits for the escapement estimate.

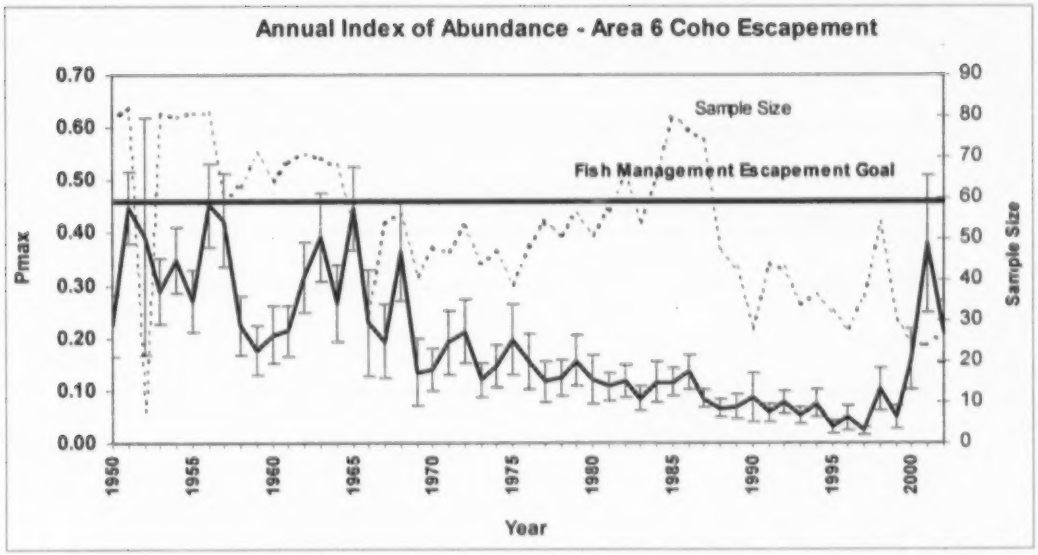

Figure 13. Time series of escapement estimates based on visual surveys of coho adults to Area 6 from 1950 to 2002. Solid line is the escapement estimate expressed as a Pmax value. Dotted line is the number of streams used to calculate the Pmax value. Error bars are the 95% confidence limits for the escapement estimate.

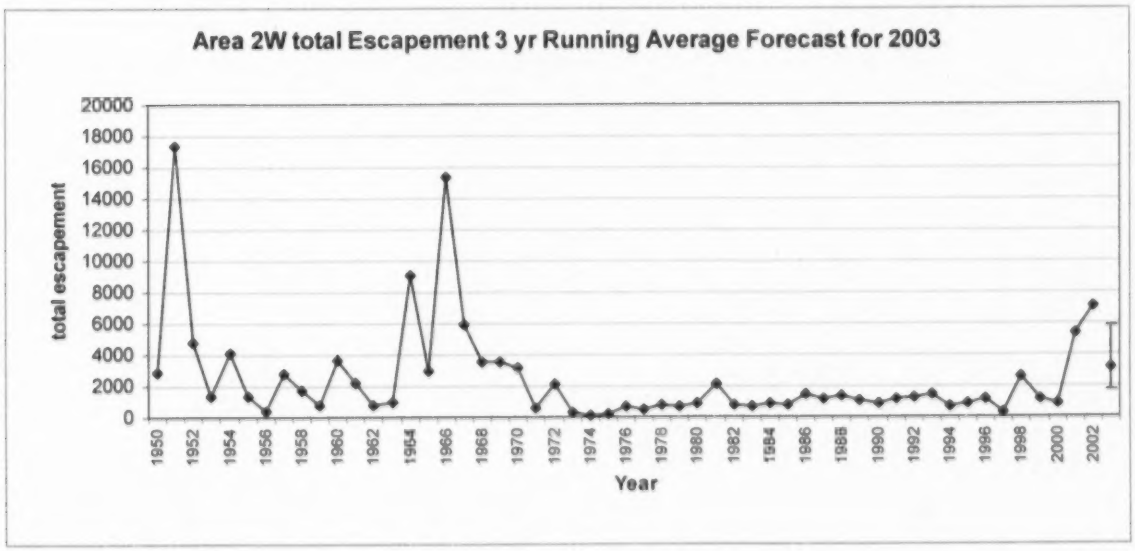

Figure 14. Forecast of total coho escapement to Area 2W for 2003 using a 3-year running average. Error bars represent the 50% CI around the estimate. Time series of escapement estimates based on visual surveys of coho adults to Area 2W from 1950 to 2002.

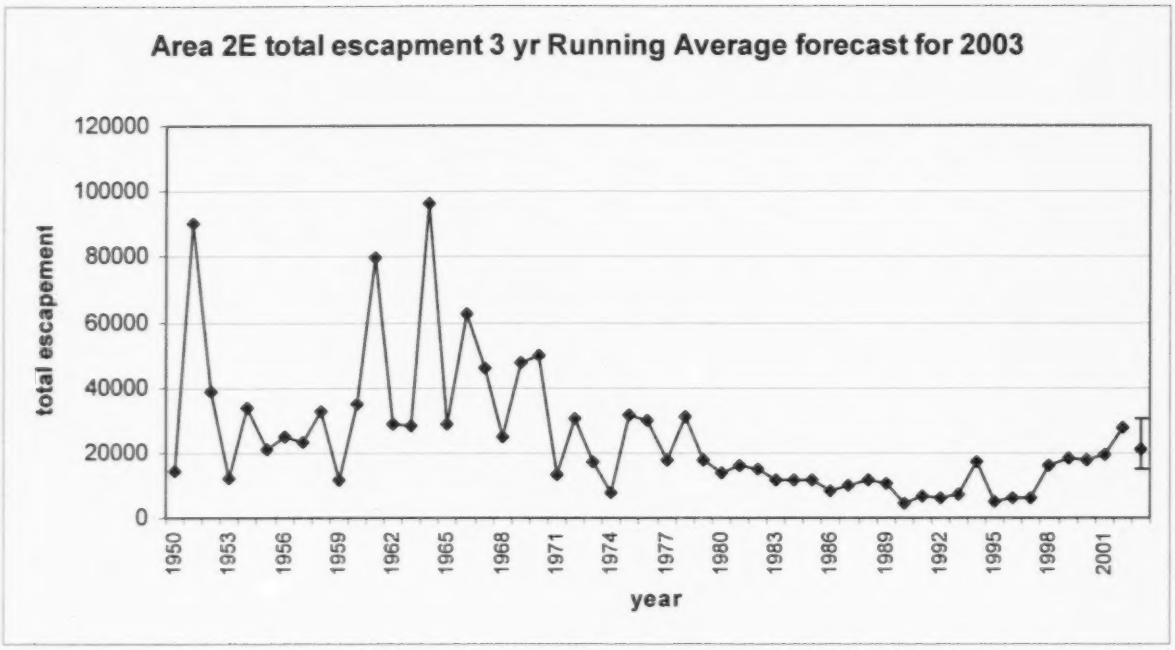

Figure 15. Forecast of total coho escapement to Area 2E for 2003 using a 3-year running average. Error bars represent the 50% CI around the estimate. Time series of escapement estimates based on visual surveys of coho adults to Area 2E from 1950 to 2002.

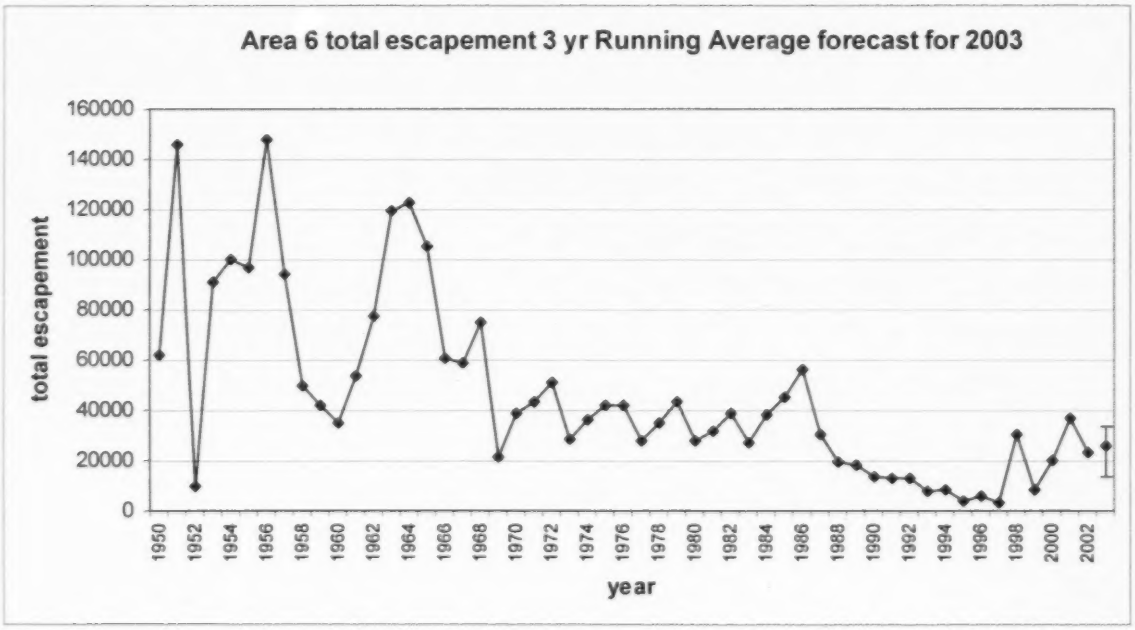

Figure 16. Forecast of total coho escapement to Area 6 for 2003 using a 3-year running average. Error bars represent the 50% CI around the estimate. Time series of escapement estimates based on visual surveys of coho adults to Area 6 from 1950 to 2002.